

SOME CASES OF ABNORMAL ARM STRUCTURE IN RECENT CRINOIDS.

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Several cases of abnormal arm structure among the recent crinoids, especially the comatulids, have been recorded by Dendy, Bateson, W. B. and P. H. Carpenter, Chadwick, and Sars; and it is the object of the present paper to put on record some additional cases which have recently come under the author's observation.

Rhizocrinus lofotensis M. Sars. Although Sars has shown that this species in the Lofoten Islands varies in the number of its arms from four to seven (recording, out of a total of seventy-five specimens, thirty-two with four, six, and seven arms, and forty-three with the normal five) those recorded from the American side of the Atlantic have all been five-armed. I have a specimen before me, however, from *Albatross* Station No. 2666, $30^{\circ} 47' 30''$ north latitude, $79^{\circ} 49' 00''$ west longitude (between the Bahamas and Cape Fear, North Carolina), 270 fathoms, which has six arms, showing that this variation, though comparatively rare, does occur on the American coast.

Pocilometra acela (P. H. Carpenter). The only specimen of this species which was dredged by the *Albatross* off southern Japan has a third costal inserted between the normal two on one of the rays (fig. 1), as was the case in a specimen of *Thaumatometra alternata* dredged by the *Challenger* just north of New Guinea. The radials in this specimen are entirely hidden by the centro-dorsal. Mr. Frank Springer, in his monograph on *Urintacrinus*, figures a specimen of *U. socialis* (Plate III, fig. 2) with four costals on one ray, an additional pair being inserted between the normal costals and the first branchials; from the shape and proportions of these additional costals in this specimen one might almost infer that they were united by syzygy, in which case the costal series would be directly comparable to the distichal series in comatulids with 4 ($3 + 4$) distichals; the



FIG. 1. — *POCILOMETRA ACELA*:
COSTAL SERIES
WITH INTERCALATED JOINT.

presence of 4 (3 + 4) costals has only once been detected, but there is no reason to believe that it does not more or less commonly occur.

Himerometra stylifer (A. H. Clark). (Fig. 2.) A specimen of this species from Kagoshima Bay, Japan, has one arm (arising on the inner side of an exterior palmar axillary) which divides at the sixty-fourth free brachial; this axillary joint bears a pinnule on the left side; on its distal faces it bears two brachials, that on the right side bearing a pinnule externally, that on the left with none; these are followed each by a syzygial pair, which, like the preceding joints, are interiorly united; that of the left-hand side bears a pinnule on its interior distal corner; the following joints on each arm are normal, and bear pinnules alternately, as usual, except that the pinnule of the second joint beyond the syzygial pair on the left side is only visible in ventral view, being forced from its usual position by the basal joints of the pinnule of the left syzygial pair, which have grown fast to its lateral border. In a dorsal view, it is seen that the left-hand arm continues the arm anterior to the axillary forward almost in a straight line, while the right is at a considerable angle; this is especially evident from an examination of the ambulacrum on the ventral side of the arm. From the presence of a pinnule on the axillary and on the opposite side one of the following joints, it is clear that this is an arm division in no way homologous to the arm division resulting from a costal or palmar series; the shape of the joints following this axillary also shows them to be distal brachials, and the tubercle always present at the junction of a first and second brachial in this species is lacking. It seems to be best interpreted as a case of *arm splitting*, where one of the distal brachials has, for some cause or other, divided (leaving its pinnule on the half opposite to the pinnule of the preceding joint, now become an axillary); the next joints (a syzygial pair) have become separated still more (only one of them bearing a pinnule), while from here onward each of these syzygial pairs bears a perfectly developed arm.



FIG. 2.—HIMERO-
METRA STYLIFER: DISTAL
ARM DIVISION.

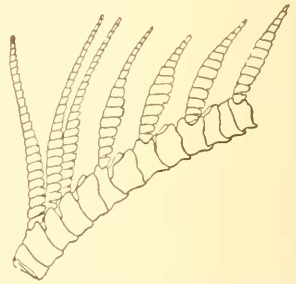


FIG. 3.—CHARITOMETRA IMBRICATA: SHOWING THREE SUCCEEDING PINNULES ON THE SAME SIDE OF THE ARM.

Charitometra imbricata (= *Antedon granulifera* P. H. Carpenter 1888, not *Antedon granulifera* Pourtalès 1878 = *Comatula brevipinna* Pourtalès 1869 = *Antedon pourtalesii* P. H. Carpenter 1888). (Fig. 3.) In this specimen the third and fourth brachials are not united by syzygy, as usual in an arm springing from a costal axillary, and the fourth brachial, instead of bearing a pinnule on the opposite

side from the second, as would be the case were the third and fourth united by syzygy, bears it on the same side, as is always the case when the second and third and third and fourth brachials are united by muscular articulation. But the third brachial is peculiar in bearing a pinnule on the same side as those of the second and fourth instead of on the opposite side.

Heliometra tanneri (Hartlaub). (Fig. 4.) A specimen of this species in the collection of the University of California, for the privilege of examining which I am indebted to the kindness of Prof. W. E. Ritter, is peculiar in having an additional first and second brachial on one arm, inserted between the costal axillary and the normal first and second brachial. This interpolated pair of brachials is, in reality, a *distichal series*, but with the more distal of the pair not an axillary; following the costal axillary, the joints may be described as follows: First, a first brachial, apparently in every way normal; then a second brachial, but of the type belonging to the opposite arm of the pair, and therefore bearing the pinnule *interiorly* instead of *exteriorly*; following this is a normal first brachial, succeeded by a normal-second brachial, and the succeeding brachials as usual. This is interesting in being the only case in the thousands of specimens of species of this genus which I have examined in which a distichal series was present; and in this case it does not result in an extra arm, as the joint, which is in reality the distichal axillary, bears a pinnule instead of the normal arm. It strongly suggests that the power of producing a distichal series and additional arms, latent in many ten-armed species of different genera, and in the case of *Antedon bifida* even in genera belonging to the same family, is quite absent in *Heliometra*.



FIG. 4.—*HELIOMETRA TANNERI*: SHOWING AN ARM WITH THE FIRST TWO BRACHIALS REPEATED.

Heliometra marina (A. H. Clark). (Fig. 5.) In a previous paper I restricted the family Antedonidae, making it equivalent to the "Tenella" and "Eschrichti" groups of Dr. P. H. Carpenter, and the genus *Promachocrinus* as redefined by Minckert—that is, including only the species *kerquelensis* and *rankhöffenianus*. This was done on the basis of arm and pinnule structure and the structure of the distal radial faces. I placed *Promachocrinus* (restricted) next to *Heliometra*, believing it to be merely a meristic variation from that type, in the same way that *Decametrocrinus* is a meristic variation from *Pentametrocrinus*. A specimen of *Heliometra marina*, taken off the southern part of Sakalin Island, appears to corroborate my views as to the origin of *Promachocrinus* from *Heliometra*, or some very similar form. This specimen has twelve arms, arising from six costal axillaries, which in turn rest upon six

first costals; the radials are, unfortunately, concealed. This twelve-armed condition is not due to the addition of an extra ray with a six-rayed rosette and six basal rays, as in the case of the six-rayed individuals of *Tropiometra carinata*, for two of the costal series are found between two of the small tubercles representing the ends of the basal rays, showing that these two series either both spring from a single radial or from a divided primitive radial. These costal series are also closely crowded, with their axes approximately at right angles, the adjacent sides of the first costals projecting considerably from the centro-dorsal, the opposite sides mainly concealed beneath it. The arms borne by these two costal series and the arms on the four other costal series are normal in structure;

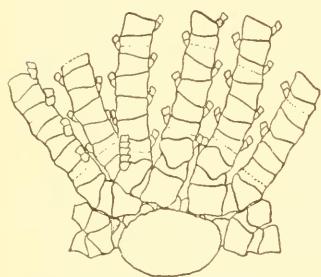


FIG. 5.—*HELIOMETRA MAXIMA*; WITH TWO COSTAL SERIES IN ONE INTER-BASAL AREA.

but the outer arm of the left-hand one of the double costal series has the first brachial fused with the axillary of the adjacent costal series, the second brachial fused with the dorsal surface of the first brachial and lower part of the second brachial of the same series, with its pinule arising from a point over the second brachial of the normal arm, and its third and fourth brachials (syzygial pair) fused with the lateral edge of the second brachial of the normal arm; the remaining brachials of the two arms are free.

The only other recorded case where two costal series arise from a single radial is recorded by Dr. P. H. Carpenter in *Comaster alata* (*Actinometra pulchella*); but here the radial bears two costal series which are smaller than the others, while in the specimen of *Heliometra eschrichtii* the two costal series are just as well developed as the normal ones.

I consider this specimen of *Heliometra maxima* to be a variation toward the condition found in *Promachocrinus*; and it seems to show that *Promachocrinus* may be derived from *Heliometra* by a simple division, or doubling, of the radials at an early stage of growth, each resultant half of the primitive radial being of equal vegetative power. The basal rays of the adult *Promachocrinus* lie under one of a pair of radials, instead of between the pairs, as would naturally be expected, this change in position possibly occurring through a predominance of pressure on one side of the anal plate as the latter is lifted out from between the radials.

In *Decametrocrinus*, the ends of the basal rays are visible between the pairs of radials, and not under one of them, as in *Promachocrinus*. This suggests a fundamentally different condition in the early stages

of *Decametrocrinus* from that found in *Promachocrinus*. In *Helio-metra*, as in *Antedon bifida*, the only plate separating the radials in the young is the anal, and it is possibly to the resorption of this plate and the subsequent filling up of the resultant gap that the torsion of the calyx in *Promachocrinus* is due; there is no such torsion in *Decametrocrinus*; might not the inference be made that in the young a similar plate occupied *all* the interradi-al areas! We get this state of affairs in *Thaumato-crinus*, which I have already shown resembles the Pentametrocrinidæ (*Pentametrocrinus* and *Decametrocrinus*) in arm structure; and it may well be that the young of *Pentametrocrinus* and *Decametrocrinus* will be found to be very similar to, or identical with, *Thaumato-crinus*.

Mr. Springer has recorded a number of abnormal arm structures in *Uintacrinus socialis*, and it is interesting to compare these with similar cases among recent comatulids. In *Uintacrinus* the lower pinnules are arranged somewhat differently from what they are in most comatulids; the first is on the outer side of the second joint from the costal axillary, the next on the inner side of the fourth joint, then on the outer side of the fifth, the inner side of the seventh, and then alternately on every joint (except hypozygals of syzygial pairs). This is not such an anomalous arrangement as it may seem at first sight, for it really means that the first two joints beyond the costal axillary are distichals, not true brachials, the joint corresponding to the distichal axillary merely bearing a pinnule, not another arm. This is similar to the case in *Eudiocrinus* (as restricted), in which genus the costal "axillary" bears a pinnule instead of the second arm. The true free arm in *Uintacrinus*, therefore, starts at the third joint from the costal axillary, this being in reality the first free brachial; the fourth and fifth free brachials (sixth and seventh joints from the costal axillary) appear to form the first syzygial pair. In most comatulids the third and fourth free brachials constitute the first syzygial pair; but it need not surprise us to find the first brachial syzygy in *Uintacrinus* one joint farther on, as in its nearest relatives, the Comasteridæ, the position of the first brachial syzygy is, according to species, between the first and second, second and third, or third and fourth brachials, while in the *Pentametrocrinidæ* the first syzygy is between the fourth and fifth free brachials, just as in *Uintacrinus*.

Considering the first two joints beyond the costal axillary as in reality distichals, we should expect to find that occasionally an arm was developed here, instead of the more common pinnule; and Mr. Springer (Plate vi, fig. 9) figures a specimen in which this condition occurs. The left arm of this distichal pair has a pinnule on the first joint beyond the distichal axillary, but this is due to the omission of the preceding joint; this joint corresponds to the axillary of a *palmar* series, the free brachials beginning at the next joint.

In a genus in which the distichal "axillary" commonly bears a pinnule instead of a second arm, one might expect to find individuals in which the costal axillary was similarly altered: Mr. Springer (Plate VI, fig. 8) figures a case in which the second costal bears a pinnule; the two distichals are present as usual, the second bearing a pinnule on the opposite side from that of the second costal.

A rather peculiar condition is figured (Plate VI, fig. 7) where apparently the distichal pinnule is on the inside instead of the outside of the arm; in other words, the two offshoots from the second distichal, the arm and the pinnule, have exchanged places; this specimen is further abnormal in lacking the first distichal.

The distichal series of two joints of which the second is not an axillary, but bears a pinnule, like the second costal in *Eudiocrinus*, would seem to be a retrogressive character, as in all other comatulids the second distichal (or fourth when doubled—i. e., (3+4)) is axillary, just as the simple pinnule-bearing second costal of *Eudiocrinus* appears to be retrogressive; we should, therefore, expect that in the young *Uintacrinus* the second costal would appear more like an axillary than in the adult. On consulting Plate III, fig. 4, and Plate VI, fig. 4, we find this to be the case; the second distichal has distinctly the appearance of an axillary joint.